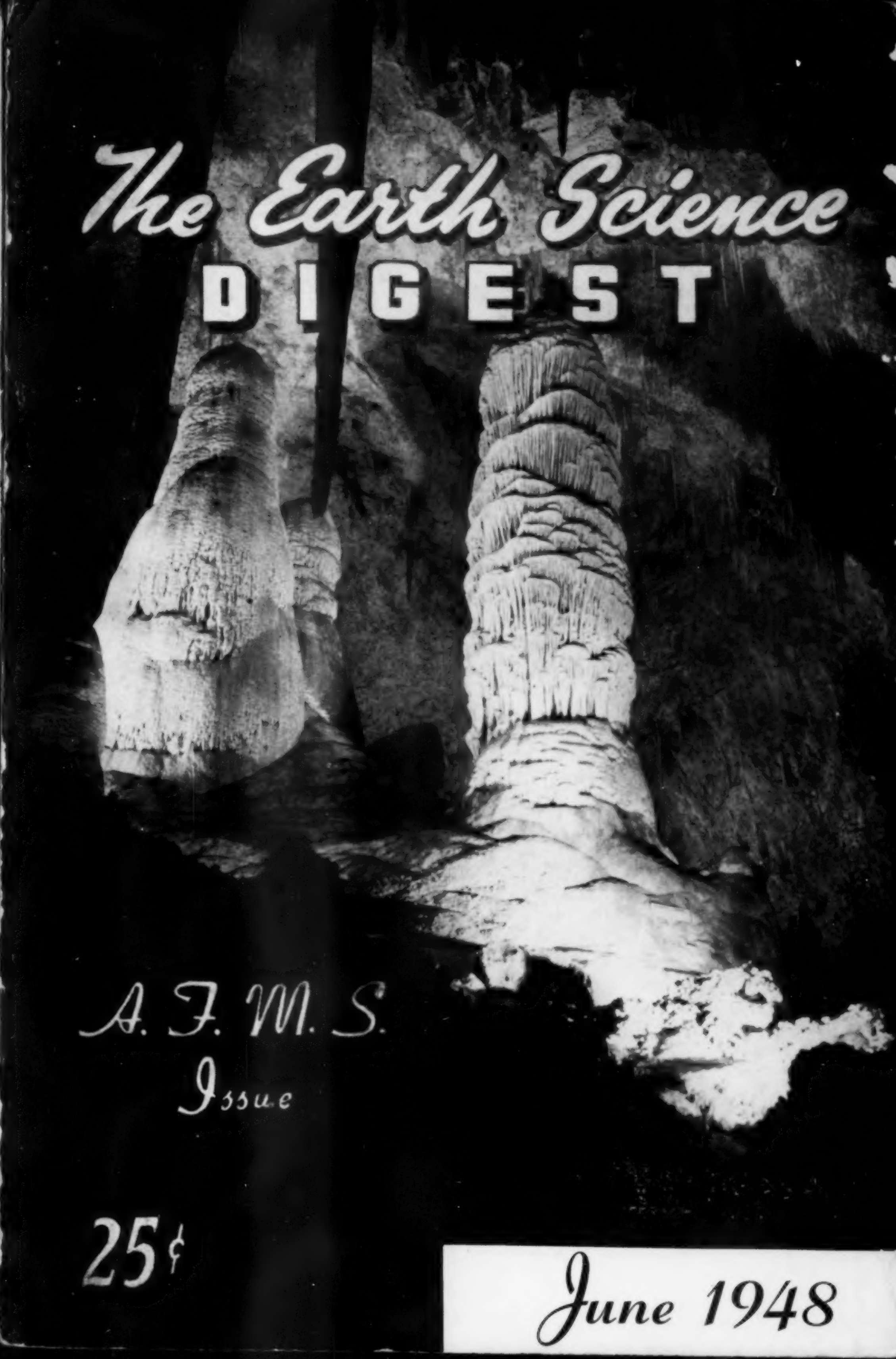
The Earth Science DIGEST



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The Earth Science Digest

Revere, Massachusetts

A magazine devoted to the advancement of the geological sciences.

Jerome M. Eisenberg, Editor

THE EARTH SCIENCE DIGEST is open to articles of geologic interest. Manuscripts, photographs and sketches will be returned if accompanied by ample first-class postage.

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Contents

AMERICAN FEDERATION OF MINERALOGICAL SOCIETIES

The First National Convention of the American Federation of Mineralogical Societies will be held from the 13th to the 16th of this month at Denver, Colorado. For the first time, earth scientists, both amateur and professional, from every state in the country, will gather to discuss their mutual interests and problems.

We are pleased to present in this issue a message from Ben Hur Wilson, president of the Federation, concerning the future growth of the earth sciences in the United States and what we can do to bring it about.

We hope the article on Colorado minerals by Richard M. Pearl, vice president of the Federation and convention chairman, will prove to be of assistance to those visitors at the Convention who plan to attend one of the many field trips leaving Denver on June 17th or who wish to do some collecting on their own.

The Editor will attend the Convention and hopes he will meet many of the readers of *The Earth Science Digest.*

COVER PHOTO

The "Giant Dome" is one of the millions of fascinating formations to be seen in Carlsbad Caverns National Park in southern New Mexico. The Caverns are estimated to have been sixty million years in the making. Photo by Wyatt Davis.

COLORADO MINERAL LOCALITIES

RICHARD M. PEARL
Colorado College

Climax Molybdenum Mine. Bartlett Mt. on left. Town in center. Tailings dump in foreground.

In the sixth edition of *Dana's System of Mineralogy,* Colorado led all the rest of the states in the number of different mineral species listed. Although since that date the record has probably gone to the larger state of California, nevertheless Colorado is one of the most highly mineralized areas in the world. This amazing variety of minerals is significant from the standpoint of the mining industry, as well as that of the mineral collector. Unlike Arizona, Utah, or some other Western states, Colorado is noted for its many mining properties rather than for a relatively few large ones. The great Climax Molybdenum Mine at Climax, near Leadville, is probably the only one that can be regarded as in any way comparable in size to the really large mines of the American West.

Consequently, the enormous mineral production that has come from Colorado since 1858 must have been largely the output of numerous small individual properties that combined to yield an aggregate of two billion dollars worth of metals, in addition to another billion dollars worth of nonmetals and coal. Colorado ranks first in total American production of silver, radium, vanadium, uranium, and molybdenum, as well as second in gold, third in

lead, fourth in zinc, and fifth in copper. Inasmuch as mineralization of any kind is likely to vary from place to place, such a wide dissemination of ore deposits in Colorado has been accompanied by an equally wide variety of minerals.

Ore minerals are not the only kind found in the state. At least half a hundred species and varieties of gems are known in Colorado. There are, in addition, a large number of minerals which, even when treated, do not profitably yield anything of value, but which are inherent parts of the rocks that constitute the earth's crust; these are called rock-forming minerals.

As should be expected, a large number of minerals have had their first discovery in Colorado, and over forty have been named after Colorado persons or places. These places include mines, streams, mountains, towns, counties, and the state itself. The mercury telluride, coloradoite, originally found in the Keystone mine, Magnolia mining district, Boulder County, was the first mineral to bear a Colorado name.

One of the important reasons for the unusual variety of minerals in this one state lies in the diversity of its geology, which in turn is reflected in its topography. Being a political rather than a topographic unit, Colorado partakes of the character of each of the adjacent states. In this respect it is excelled only by Missouri, which has eight states touching its borders, one more neighbor than Colorado's seven. Colorado's southwest corner, in the Four Corner's section, is the only place in the nation where four states come together. Colorado lies within five natural regions or physiographic provinces, which is true of but one other state, Tennessee.

The three major regions represent broad north-south zones. On the east are the Great Plains, entering the state from Nebraska and Kansas at an altitude of 3,350 feet above sea level and rising steadily to 6,500 feet at the edge of the mountains. The central zone is the Southern Rocky Mountains, which culminate in the highest 14,000-foot peaks of the Sawatch Range, which Will Rogers colled "the ridgepole of the continent." The Colorado Plateaus extend westward from the Rockies into Utah, and range in altitude from 5,000 to 11,000 feet.

The smallest natural regions are the southeastern edge of the Middle Rocky Mountains, separated from the other Rockies of Colorado, and the Wyoming Basin, a rolling prairie interrupted by streams and isolated mountains.

Each of these five areas is characterized by its own types of geology, its own kinds of rocks, and its own assortment of minerals. Certain ubiquitous minerals are, of course, not restricted to specific regions. Gold, for example, is "where you find it," but even gold is searched for with more success in some rocks than in others. The "lucky" mineral collector is generally the one who has a keen sense of the appropriateness of the rock relationships and mineral associations in the place where he is working, based usually on extensive experience.

The seasoned collecter would thus expect to find the sulfide and other ore minerals in the mountainous parts of Colorado. Weathered specimens of minerals such as pyrite, chalcopyrite, galena, and sphalerite, can be picked up on almost any mine dump in

Mount Antero from the top of Mount White

the hills; with them will be found the usual gangue minerals, including quartz, barite, rhodochrosite, and fluorite. The rich array of pegmatite minerals would likewise be expected in the "hard rock" of the mountains. The same veteran collector would look for nodules and aggregates of certain common minerals in the sedimentary formations flanking the mountains and spreading across the plains. Here are found the interesting aragonite twins, marcasite groups, and cubic goethite pseudomorphs after pyrite.

This bird's-eye method of collecting has many practical limitations. Yet a good deal about the possibilities of a given part of the state can be learned by careful examination of a geologic map, even a topographic map, of Colorado. The mineral maps of Colorado show clearly the strategic situation of the most highly metallized area, which stretches in a general southwest direction from Jamestown in Boulder County to the La Plata Mountains in the "golden San Juans."

The recent discoveries of nahcolite is an interesting example of the relationship between geologic conditions and mineral collecting in Colorado. Nahcolite is a most peculiar mineral, being sodium bicarbonate, natural baking soda. It was formerly a rare mineral, originally found lining the walls of an old tunnel about nine miles west of Naples. Now it is known in fairly large amounts in the oil shale of western Colorado. Except for the ocean, this oil shale is the largest single "mineral deposit" in the world. It covers 1,000 square miles; the oil-bearing beds are as much as 1,300 feet thick, although the horizon being emphasized is 70 feet thick. Long after the liquid petroleum reserves in this country have been depleted, fuel will still be obtainable from Colorado's oil shale.

The highest mineral and gem

Ruby Mt. Nathrop in Foreground

locality in North America is Mount Antero in the Sawatch Range. In pegmatite pockets on the sides and virtually at the top of this 14,245-foot peak, accessible only with difficulty, are found crystals of aquamarine, the blue variety of beryl. They range in color from light blue to an occasional deep blue, and are etched in an interesting and characteristic manner. Associated with the beryl, and presumably derived from it, are crystals of phenakite, Antero being the most important locality on the continent for this beryllium silicate mineral. Bertrandite is another beryllium silicate occurring here in rare but sometimes choice crystals. Beautiful octahedrons of purple fluorite and fine crystals of rock crystal and smoky quartz also await the successful (and persevering) collector at Mount Antero.

Only a few miles away, across the Arkansas River at Nathrop, are three volcanic hills of more than average interest. The rhyolite is much like that which constitutes the mass of Topaz Mountain in the Thomas Range of Utah. At Nathrop, however, topaz is much smaller and far less common, whereas garnet is much more abundant than in the Utah desert. The tiny sharp reddish brown crystals of spessartite garnet in cavities (called lithophysae) in the light-gray rock make exquisite specimens, but the rock is not easily removed from its place. The local inhabitants call these garnets "red rubies" to distinguish them from the "black rubies," which are spherulites of obsidian, called marekanite, occurring as glassy pebbles in the perlite phase of the rock body.

Several other important mineral localities occur elsewhere in and near the Arkansas Valley. Four miles north of Salida, at the Sedalia copper mine, are found the giant garnet crystals that are so well known in museums all over the world. The crystals are dodecahedrons and they have been reported as weighing over 15 pounds. They are almandite garnet of remarkable perfection of form, but they have undergone considerable surface alteration to chlorite, similar to the chlorite schist in which they are embedded. Removal is fairly easy, and a suite of these specimens graded in size could be an attraction in any collection.

In the vicinity of Salida is one of the most prolific areas in Colorado, producing igneous, sediment-

ary, and metamorphic minerals in wide variety. Several interesting places are situated around Turret, a ghost town, 11 miles into the hills from Salida. Here are found sapphire, corundum, epidote, actinolite, pyrophyllite, and other specimens. In the other direction from Salida is an important travertine quarry, material from which has been used for building purposes throughout the United States. To be fully appreciated this region must be traveled through, camped in, and examined in detail.

Going south from Salida over Poncha Pass, the collector looks down upon an amazingly level land that reminds him of the dried bed of an ancient lake. That is exactly what this part of the San Luis Valley is. Shaped like a mitten, it is bordered on the east by the majestic Sangre de Cristo Mountains, which rise above 14,000 feet and descend again to the plains within a distance of five or six miles. The San Luis Valley is a land of contradictions, not the least of which is the fact that, although it has less rain than any other place in Colorado, more than 3,000 artesian wells gush forth floods of pure cold water.

Along the eastern edge of the San Luis Valley spread the largest and highest sand dunes in the country. The choicest part is included in the Great Sand Dunes National Monument. Reports have it that the gold content of the sand is valued at eight billion dollars, but no one has ever succeeded in obtaining any of it profitably. Samples of this sand are interesting to collect and study.

The leading turquoise mine in the United States is in the San Luis Valley, nine miles west of Manassa. Last year it produced over $30,000 worth of the blue

Face of Main Pit, King Turquoise Mine near Manassa.

gem, almost as much as the entire output of the state of Nevada. From this King Mine has also come the largest turquoise nugget ever found; this huge piece is on display in the Bureau of Mines Museum, across the street from the State Capitol Building in Denver. Another turquoise mine, the Hall mine, was the largest producer in the state a few years ago; it is located between Villagrove, a town in the San Luis Valley, and the Bonanza mining district in the Cochetopa Hills, which form an extension of the San Juan Mountains at the western edge of the Valley.

Plume agate, the newest addition to Colorado's long list of mineral varieties, occurs in nodules near the west-central border of the San Luis Valley. It occurs in almost every color and combina-

Pikes Peak Photo by Robert Chadbourne

tion of hues, and the patterns are equally varied.

The once-fabulous mining town of Creede, in Mineral County, lies in the San Juans about 25 miles out of the San Luis Valley. The rich silver deposits of this locality contain a large quantity of amethyst—massive, crystallized, and in clusters in vugs. Specimens of banded amethyst, alternating with white quartz and cut by ore veinlets are immediately recognized as having come from Creede. They may be picked up on numerous mine dumps.

As a scenic feature the Royal Gorge of the Arkansas is internationally known. As a mineral locality it is equally outstanding. The pegmatites in the vicinity of Canon City have yielded many different kinds of uncommon minerals. In 1906 several deposits in Eightmile Park were the chief producers of tourmaline gems in the United States outside of California.

Although far below the highest mountain in America, Pikes Peak is surely the most famous. It formerly gave its name to the whole of central Colorado, so that the older mineral specimens in museums and private collections bearing a Pikes Peak label may have come from anywhere within a hundred miles of the true place. Especially conspicuous because it stands apart from the main ranges of the Rockies, Pikes Peak is composed of several phases of gran-

ite which extend over thousands of square miles to outline the "Pikes Peak region."

Pegmatites and miarolitic cavities in the Pikes Peak granite contain the most notable minerals, of which microcline feldspar (Including amazonstone, the green variety), smoky quartz, topaz, fluorite, and phenakite are af especial interest. These deposits are widely scattered and pockets may be found almost anywhere in this region. Considering the extent of the area and the relatively small size of practically all the individual pockets, there must be a tremendous amount of material remaining to be discovered in the centuries to come.

Among the localities in the Pikes Peak region that should be especially noted — and visited — are Florissant, Crystal Peak, Cheyenne Mountain, St. Peter's Dome, Crystal Park, and Devil's Head. Similar in geology, these places nevertheless have their own distinctive mineral associations which are recognized by experienced collectors. Specimens of smoky quartz and microcline from any of these localities are probably more in demand over the United States than any other Colorado minerals.

The nearest to Denver of the world-famous mineral localities in Colorado is the zeolite deposit at Golden. Just outside this town, which houses the Colorado School of Mines, are two basalt mesas called North and South Table Mountains, which were formerly connected before Clear Creek cut between them. The former is the best place to collect. Nine or more different kinds of zeolites, as well as several other minerals, come from this locality. The minerals range from substantial single crystals, such as analcime and apophyllite, to delicately matted needlelike crystals, such as mesolite.

Ferberite, the iron tungstate mineral, is more abundant in Boulder County than anywhere else in the world. The sparkling black crystals that line openings in the ore veins make exquisite specimens. Surrounding the town of Nederland and extending eastward along Boulder Creek, this tungsten district led the rest of the United States in the production of the metal from the beginning of the century until the recent war. During the period of high prices during World War I, good pieces of ferberite were too valuable to be kept as specimens. Numerous mines and prospect holes dot this area.

Northwest of Boulder, near Jamestown, is the main fluorspar district of Colorado, ranking second in the United States to the Illinois-Kentucky deposits, though far inferior to them in volume and even more so in the quality of the specimens. In this same area, however, is an especially interesting kind of mineralization, represented by radioactive and rare-earth minerals. The first discovery of cerite in the United States and the fifth in the world was made here. With the cerite are uraninite (the primary radioactive mineral) and the following rare-earth minerals — allanite, tornebohmite, bastnasite, monazite, and brown epidote. The age of the rock has been determined by the lead-uranium method to be 940 million years.

The mineral collector can secure a generous assortment of attractive specimens from the sedimentary beds along the Foothills of the Front Range in northern Colorado. The nodular aggregates of marcasite crystals should surely be mentioned. More curious than

these are the flat six-sided twin crystals of aragonite. Like the garnet crystals from near Salida, they are found to grade closely in size, so that a group may be selected to range from very small to perhaps six inches in diameter, with no gap apparent along the line. The early settlers called these disklike crystals "Indian dollars."

The largest alabaster workings in the United States are located in this same general area, especially in the Lykins formation in the vicinity of Owl Canyon and Livermore, about 18 miles northwest of Fort Collins. Alabaster is a dense, fine-grained variety of the common mineral gypsum. The Colorado material is most attractively veined in hues of brown, and a considerable local industry has been built up in the carving of ornaments, especially vases, lighthouses, and trays. Distributed in favorable spots throughout the massive gypsum are occasional crystals of selenite, the transparent variety of gypsum.

On the northeastern plains of Colorado, near the town of Stoneham, is the noted blue barite locality. The beautiful crystals are easily removed from the loosely consolidated claylike rock in which they are embedded. Some crystals are entirely transparent, many are terminated, and a few are a satisfyingly good size. Both single crystals and groups are found.

The chalcedony varieties of quartz that are so widespread throughout all the Western states have not been omitted from Colorado. Agate, jasper, and petrified wood are the most abundant varieties. Petrified wood, typically yellowish-brown, may be found almost anywhere on the plains east of the mountains; Elizabeth and Kiowa in Elbert County and the Pawnee Buttes area are especially well-known localities. The Petrified Forest near Florissant is another major locality. Richly colored agatized dinosaur bone is found around La Junta, though not in the quantity that comes from near Grand Junction and elsewhere in the western part of Colorado. Jasper pebbles similar to the South Dakota material may be picked up in almost any amount near Kalouse in Weld County. Yellow, brown, blue, and white chalcedony occurs in each of the great intermountain basins—North Park, Middle Park, South Park, and the San Luis Valley. A mere listing of the known chalcedony localities in Colorado would occupy pages.

Ranging sixth among all mining districts in the United States in total production, the Leadville district is conspicuous for the variety of its minerals. None of these, however, exceeds pyrite in interest to the mineral collector. The huge cubes of pyrite, measuring half a foot across, are known everywhere. Likewise, the so-called cathedral pryite from the Ibex mine is a distinctive kind of specimen, its symmetrical arches or windows fully justifying the name.

As previously mentioned, the molybdenum mine at Climax, high on the Continental Divide, 13 miles north of Leadville, is the largest mining operation in the State. Specimens of molybdenite in granite are typical of Colorado as any mineral can be. The mineral is silvery-gray in color and marks paper as graphite does. Inasmuch as this is a low-grade large-scale deposit, the molybdenite is found in narrow stringers which criss-cross the rock in all directions. Over 40 million tons of this rock has been mined and the reserves are at least five times as great.

Working the Gem Mines near Florissant

High on the slopes of North Italian Peak, in the Elk Mountains of Gunnison County, is a substantial deposit of lapis lazuli which compares favorably in its rich blue color with the Oriental material. It has the characteristic golden flecks of pyrite and white wisps of calcite, and when properly polished it has a fine luster. Not much of this gem has yet been made commercially available from here.

Carnotite has become the most talked-about of all Colorado natural resources. This canary-yellow mineral is a source of three important metals—uranium, radium, and vanadium — and has been mined for all three. Originally it was regarded only for its radium content and the rest was discarded; vanadium was next sought for as a steel alloy, and now uranium is the key product. Nowhere else in the world is there so much carnotite as in the west-central counties of Colorado, in a vast barren area, once inhabited by Cliff Dwellers, that extends across the border into Utah. The carnotite is found disseminated in sandstone and replacing petrified logs — a unique occurrence. Two logs and the intervening sandstone are reported to have yielded over a third of a million dollars in the three metals extracted.

This general survey of some of the more noteworthy of Colorado mineral localities stands as an invitation to visit them and take advantage of what they have to offer.

THE AMERICAN FEDERATION AND EARTH SCIENCE EXPANSION

BEN HUR WILSON

President, American Federation of Mineralogical Societies.

Ben Hur Wilson

In times such as these when there appears to be much overextension and expansion along many lines, it is, indeed, refreshing to find some field of worth while human endeavor, yet practically virgin insofar as its ultimate potential development is concerned.

Earth Science, with all its many branches and ramifications, running through so much of the cultural and practical fabric of our civilization, presents just such a picture; and it is our purpose to clarify and elaborate upon this statement in the remarks which follow.

It is true that there has never been a time in the entire history of our country when there was an apparent need on the part of the masses for the development of some broad, tangible subject in which they might become deeply interested. This, no doubt, to many would prove a godsend as it would serve to take their minds completely off themselves and their own worries and concern for the future.

Of all the avocations, Earth Science presents some of the very best qualifications for fulfilling this great need. It quickly changes people's perspective and their entire attitude toward living and problems of the day; introverts quickly are converted into extroverts.

There are two other factors which are also worth considering at this time. (1) As an integral part in the development of our national life, we are, without doubt, on the verge of vast expansion in adult education. This is a problem which has been altogether too long neglected. (2) Then, there is the question of what men are to do with their increasing leisure time. The shortening of our working day, and the increase of our population is fast bringing this problem to the forefront.

The situation, I feel, is like this, using an illustration which all Earth Scientists may well understand. One may produce a supersaturated solution, which undisturbed may remain fairly stable for an indefinite period of time. However, one need only introduce

a small "crystal seed" into it, and it will quickly crystallize into a solid mass, almost as if by magic. I am quite certain that we have today in the educational life of our country an analogous situation of striking similarity.

Throughout the entire country, there exists an intense desire on the part of a great number of people to learn not only more about the Earth, but also of the rocks and the minerals of which it is composed, or in other words, what makes it click. That the demand is here and pressing, is shown by the spontaneous organization of the many existing Earth Science study groups without direct promotional activity. There can be little doubt, but that this demand is fast reaching the saturation point; and it is my sincere conviction that with proper guidance and reasonable promotion, this show of interest may rapidly be crystallized into a forward movement of such vast proportions as to astound Earth Science enthusiasts everywhere.

All this, however, cannot possibly be brought about by an indifferent or laissez faire attitude on the part of those most interested. In fact, it may be that if the present great enthusiasm is not promptly made use of, in some manner, it may soon lapse and decline; perhaps never again to be revived within the present generation. Such has been the history of all similar movements, and we have no reason for assuming that the present Earth Science interest will be any exception to the rule.

The tide is now in, and if we do not ride it out and go forward on its crest, we will soon have lost a golden opportunity to advance Earth Science interest to the place where it might do much good in the world. With these facts in mind, and for this purpose, it was largely that the American Federation of Mineralogical Societies was organized, i.e., to promote the growth and interests of the Earth Sciences in every way. It may well be the "crystal seed" which will bring about results which may prove highly gratifying to all connected with it. It is unthinkable that we should permit this opportunity to pass without our taking full advantage of it.

Among our objectives should be: (1) An Earth Science program in every school—elementary, high school, and college.* (2) A hobby or study club in every community of 5,000 inhabitants or more. (There are today many such organizations in even smaller communities). (3) Lapidary programs, for their recreational and therapeutic value, in every rehabilitation hospital; and as a part of our city, state, and national park systems. (4) Active Regional Federations functioning in every section of the country; and, (5) Thousands of ardent individual mineral collectors scattered everywhere through the smaller villages and rural communities.

We have already come a long way toward these stated objectives, and some progress has been made in every single one of these fields. From now on the rate of advancement will depend upon the amount of energy and cooperation that can be marshalled behind the movement. This is certainly not one man's job but one which will require the united efforts of all of our publishers, magazines, dealers, clubs, federations, state surveys, and a host of others.

The field is so large that there need be no fear of any overlapping of effort or authority on the part

* "Earth Science in the Secondary Schools," by Ben Hur Wilson, *The Earth Science Digest*, December 1947.

of anyone, and it will be the principal function of the American Federation to organize, coordinate, and guide the greater movement into workable channels which will stimulate and augment the velocity of our progress. As president of the American Federation, I heartily bespeak both your cooperation and interest, as well as your sympathetic advice and counsel at all times.

A PECULIAR MANIFESTATION AMONG CRINOIDS

HARRELL L. STRIMPLE

One of the satisfactions in paleontological studies is the privilege of observing evolutionary and divergent trends found among various forms of life. These changes are so gradual they can hardly be recognized among living creatures but in the condensation of vast periods of time, represented in the sedimentary crust of our earth, it is often possible to closely follow some developments. Outstanding examples of natural and logical trends are found among certain groups of sea animals belonging to the phylum of echinoderms (star fish, etc.) known as crinoids.

Most fossil crinoids are stalked forms of life, superficially resembling plants (see fig. 4). A long stem, or column, is present, terminating with a body (dorsal cup) which in turn possesses arms. It is believed by many that through discarding the stem and living on the floor of the ocean a certain branch of crinoids probably evolved into starfish. In yet another branch, the loss of a stem brought about free floating crinoids with apparent functional success since they still exist in the ocean today. A large group of these free floating forms has been described by Dr. R. E. Peck* of the University of Missouri from a period of time known as the Cretaceous Era, and exemplify the extremes which nature is able to develop in meeting special environmental conditions.

The majority of forms disclosed in Peck's study retained a cone shaped body design common

Figs. 1-3 Free floating Cretaceous crinoids (enlarged).

Fig. 1. Sketch of the dorsal cup of Depranocrinus peracutus Peck in side view, to demonstrate the common cone-shaped cup (body).

Fig. 2. Sketch of the dorsal cup of Poecilocrinus dispandus Peck in side view, illustrating the wing like extension of upper body elements.

Fig. 3. Sketch of the dorsal cup of Orthogonocrinus aperatus Peck in side view, to demonstrate the development of heavy basal elements to provide additional "ballast" action.

Fig. 4. Diagrammatic sketch of a simple stalked crinoid to demonstrate the common cone shaped dorsal cup (body) and upward directed attitude of the arms.

Fig. 5. Outline of a star fish to demonstrate downward directed attitude of the arms.

among most simple crinoids, both prehistoric and present. **Depranocrinus peracutus** Peck is the more primary structure and is more common than the others. It is almost certain these forms retained a normal upward directed attitude because cross sectioning discloses an internal thickening of the basal elements which would serve as a ballast, and in **Poecilocrinus dispandus** there is an extension of the upper body elements to form wing like appendages which must have served the function of stabilizers

* 1943, Peck, Raymond E. Lower Cretaceous crinoids from Texas; Journ. Paleo., vol. 17, no. 5.

in rough water. In observing forms from numerous horizons, the writer has noted **P. dispandus** normally is not associated with other crinoid species; however, numerous fragments of crustaceans (crabs) have been noted indicating a shallow habitat such as proximity to shore or beach areas.

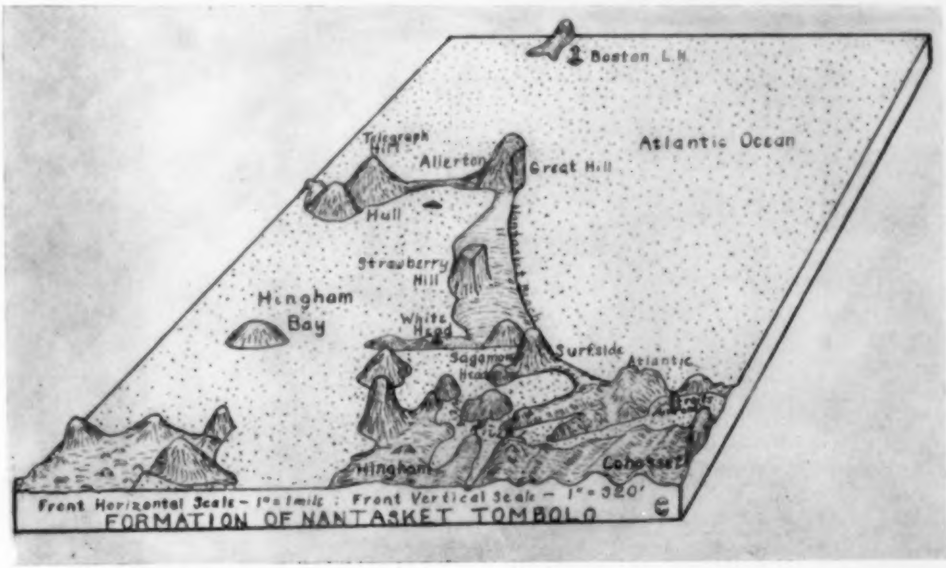
The "ballast" development is extended further among some forms as illustrated by **Orthogonocrinus aperatus** Peck (see Fig. 3) where the basal elements have become thickened and expanded.

By way of experimentation, various forms have been placed in a saucer of water and it is found that the "winged' spec'ies will float much more readily and for greater lengths of time than the other forms. This is really only a demonstration of surface-tension afforded by the greater expansions and the possession of a more perfect balance. If the forms had floated on the surface of the ocean with the arms directed downward, in a manner comparable to some of the present day jelly-fish, one would expect a reduction of weight in the basal area, and probably a provision for air storage, which is the exact opposite of the trends disclosed.

THE PAST AND FUTURE AT NANTASKET BEACH

C. W. WOLFE

Boston University



A relief diagram of Nantasket Beach, showing the disposition of land and sea prior to the extensive road building activity of man in the past forty years.

Thousands of Massachusetts folk and visitors from all parts of the world flock to the beautiful playground spot of Nantasket Beach, Massachusetts, during sultry summer days. All too often we fail to see, written into the scenes of our recreation, stories of boundless interest and fabulous events, stretching back and back in time for hundreds of millions of years.

To the geologist, however, every rock and every hill, every sand grain and every valley provides some link to the chain of time, of which man's history is so short a part. Let us study the remarkable history of Nantasket Beach as told by the rocks, for the story there is unusually clear, although many pages are missing from our "history book".

One of the first things we must do is to remove any ideas we may have of the permanence of earthly scenes. The "eternal hills" grow and are worn away in a remarkably small fraction of the earth's history. Geologically speaking, great mountain ranges, coastlines, lakes — all are temporal, evanescent features, present but for a few seconds to perhaps a few minutes in the total course of the earth's day, and then are gone. The Nantasket of today has been produced in the last few thousand years, but when we look at the rock ledges at the southeast end of the beach or in the low hills

behind the beach to the west we find rocks which were formed hundreds of millions of years ago.

It wil be useful to refer occasionally to the map of the region. It is a relief diagram of the area, showing the disposition of land and sea prior to the extensive road building activity of man in the past forty years.

We will first study the region bordering the Weir River in the south central section (the rocks east of the word "Weir"). This rock is probably more than five hundred million years old. It is called the Dedham granodiorite, a granite-like rock, and was formed perhaps a mile, perhaps several miles below the then existent surface of the earth. A veritable sea of melted rock, called magma, underlay scores of square miles of this region and invaded the rocks above. These overlying rocks have since been worn away, probably by extensive stream erosion during millions of years, and here we see exposed the heart of that old magma chamber. About three hundred and twenty-five million years ago, the entire region was lifted high above the sea and streams began to carve deep valleys into the granite. An extensive inland basin was formed to the north, and the stage was set for the great episode.

Tremendous forces operating from within caused the earth to crack open, and, rising from a depth of probably tens of miles, great masses of molten material poured out upon the surface in extensive lava flows. Volcanoes were formed whose size and quantity of exploded material are not exceeded by any of the volcanoes now extant. All of this transpired in a region of rugged topography. Contemporaneous with the outpouring of lava and the ejection of volcanic debris, swift moving streams were

Pillow lava at Atlantic. Quartz was deposited in the cavities formed by the cracking of the shrinking lava.
—Photo by E. Thompson.

pouring down the slopes of granitic and volcanic mountains, and the sand and pebbles picked up enroute were deposited in the valleys. The result of this compound volcanic and erosional activity was the formation of successive layers of lava and conglomerate until the accumulated material was hundreds of feet thick, and many of the granite hills were covered.

For example, just to the northwest of the "W" in Weir River we can see the following succession of rocks. On the bottom the granite is not to be seen, although a few hundred yards to the west the old fossil surface of the granite, on which the pebbles and sand were deposited, reveals nothing but granite. The first rock is a conglomerate made up of pebbles, de-

posited by swift moving streams, but since most of the pebbles are volcanic in character, we might better call the rock **agglomerate.** Just above this agglomerate is a thickness of fifteen to twenty feet of a very interesting lava. Evidently, when this lava issued forth, there was a large amount of gas imprisoned as bubbles in the lava. Then, as the lava flowed along, these bubbles were stretched and flattened. Later the cavities were filled by minerals as water soaked through the permeable lava rock, and the unusual appearing almond or **amygdaloidal** rock resulted. The succession following is: conglomerate, ten feet thick; lava grading into another conglomerate containing much volcanic material, forty feet thick; and finally, agglomerate. This sort of succession is typical of the rocks anywhere in the Nantasket area.

Unquestionably at least hundreds of feet of lava and conglomerate were deposited, above what we now see, before this epoc of history closed. Two hundred million years passed during which time the land probably rose and fell many times, but no record of this movement remains in the rocks. All that we know is that the present distribution of rock hills and valleys had reached its present form probably a million years ago.

About one hundred to one hundred and twenty-five thousand years ago snow began to accumulate in the Labradorian region, and in other parts of the world, faster than it melted. Before long a great continental ice cap, similar to that now seen in Antartica, had grown and had begun to push its way outward in all directions. It is entirely possible that at their centers the ice caps were as much as two miles thick. The formation

Flow structure is visible in this example of amygdaloidal lava from Nantasket.
—Photo by Jean Robertson.

of such great ice caps required a tremendous quantity of moisture which was derived from the sea. Sea level must have been lowered at least two hundred and fifty feet by this wholesale accumulation of snow.

Along the shallow bottom of Boston Bay the water retreated twenty to fifty miles; so that when the glacier reached Boston, all was dry land. Evidences of the glacial invasion of Boston may be seen on every hand. The vast deposits of sandy gravel were laid down by streams issuing from the front of the glacier. Other gravel mixed with clay is called **till** and was deposited directly by the moving or melting ice. Rock ledges were scoured, smoothed, and scratched by the moving ice, and these smoothed, striated surfaces are extremely common.

One of the most interesting acts of the glacier was the formation of hundreds of oval shaped hills, called **drumlins,** in the Boston area. Usually these hills, which are composed of till, formed around some previously existing small rock hill. After the ice had melted away, perhaps forever, perhaps to come again in another hundred thousand years, the sea began to move in upon the land again, and the processes producing our present shore line began to operate.

Let us speak of the rocky shore of Atlantic (east of the beach). Far out on the small peninsula we may see conglomerate capped by lava. At the foot of the hill we see beds of volcanic ash which were laid down in water above the lava. All of these rocks are being subjected to the ceaseless pounding of waves. The great storm waves, particularly, have succeeded in carving out prominent cliffs in the rock At the eastern end of Atlantic a small sea gorge has been carved where a sheet or **dike** of rock, which had formerly fed a volcano far above, has worn away more rapidly than the surrounding rock. As the rocks are broken from the cliffs they are churned and ground by wave and **undertow** until they are polished and smooth. Those pebbles which lie along the side of the small peninsula have developed a thick pancake-like form, since the waves there strike and move them at an angle, producing a **shingle beach.**

Gradually, the rocks were converted into sand. At the same time, wave action set in against the drumlins of the harbor. In our diagram, for example, we can see how Strawberry Hill and Great Hill have been attacked by the waves until great sea cliffs have formed. All of the materials eroded from drumlins or ledges must sooner or later be re-deposited. This is done by two agents, the undertow and **longshore currents.**

Let us suppose that currents moving across Atlantic from the east began to deposit some of their sand as a **bar** projecting westward from the peninsula. This would be formed below tide level at first, but storm waves would soon heap it up so that the top bar or **spit** would lie above high tide level. This spit would continue to grow until Sagamore Head would be joined to

A shingle beach at Nantasket. Note the pillow lava in the background.
—Photo by Jean Robertson.

Atlantic. This was the beginning of Nantasket Beach, possibly twenty thousand years ago. The bar grew out beyond Surfside to the north and eventually formed in front of Strawberry Hill, leaving the **wave-cut cliff** as evidence of its former direct contact with the sea. Strawberry Hill was then joined to Great Hill and Great Hill to Telegraph Hill, and a great sandy beach, stretching from Atlantic to Hull, was formed. When islands are tied to islands or to the mainland, the connecting bar is a **tombolo.** Nantasket Beach is a compound tombolo.

Thus we see that Nantasket Beach is but a temporary feature in an ever changing earth. Perhaps

in twenty thousand and perhaps in fifty thousand years, the drumlins of the bay will be gone, Nantasket Beach will be unknown, and Boston Harbor will be a great marshy area. Beaches now unknown will line our shores, and other geologists will tell other tales to other children of Mother Earth.

THE COLLECTOR

This section of the Earth Science Digest is devoted to the collector of minerals, fossils, and rocks. Notes on collecting, collections, localities, etc., will be welcomed. Please address all correspondence to The Collector, c/o The Earth Science Digest, Revere, Mass.

A REPRESENTATIVE MINERAL COLLECTION

— PART II —

A list of 150 important mineral species was published in the March 1948 issue of *The Earth Science Digest*. The compilation of this list was based upon those species most common in the United States, the more important economic minerals, and those minerals most often found in museums and private collections.

Since that time the writer has received a number of requests to publish a second list, comprising the rarer species which are of importance to the more advanced collector. Therefore, a second group of 150 mineral species is given below. This list is also divided into six parts; the first part consisting of those species which the writer considers most important, the second part consisting of those next in importance, etc.

The first fifty minerals of this second list are not uncommon in the majority of collections, although some of these species, in spite of their importance, are overlooked by most collectors.

Most of the last one hundred minerals on the list fall well into the classification of "rare" species, either because of their localized occurrence, their actual scarcity in the earth's crust, or, in the case of the ores of the noble and rare metals, their commercial value.

Two corrections should be made on the first list. By error, molybdenite and zircon were duplicated, and numbers 62. and 100. should be replaced by pyrolusite and gold, respectively.

(7)

151. Acmite	158. Columbite	164. Garnierite	170. Millerite
152. Andesine	159. Cordierite	165. Gibbsite	171. Penninite
153. Apophyllite	160. Covellite	166. Greenockite	172. Riebeckite
154. Axinite	161. Diaspore	167. Heulandite	173. Vanadinite
155. Borax	162. Enargite	168. Hypersthene	174. Wavellite
156. Cancrinite	163. Enstatite	169. Jamesonite	175. Wollastonite
157. Cerargyrite			

(8)

176. Allanite	183. Crocoite	189. Laumontite	195. Scolecite
177. Ankerite	184. Epsomite	190. Lazulite	196. Smaltite
178. Boracite	185. Erythrite	191. Lepidomelane	197. Tantalite
179. Brookite	186. Glauberite	192. Margarite	198. Thompsonite
180. Chalcanthite	187. Glaucophane	193. Melanterite	199. Triphylite
181. Chondrodite	188. Jadeite	194. Niter	200. Zoisite
182. Cobaltite			

(9)

201. Atacamite
202. Bismuth
203. Boulangerite
204. Bournonite
205. Brochantite
206. Chloanthite
207. Clinohumite
208. Gmelinite
209. Harmotone
210. Humite
211. Ilvaite
212. Laumontite
213. Lithiophilite
214. Norbergite
215. Octahedrite
216. Phillipsite
217. Platinum
218. Polybasite
219. Proustite
220. Pyrargyrite
221. Scorodite
222. Sepiolite
223. Tennantite
224. Turgite
225. Vivianite

(10)

226. Arfvedsonite
227. Bindheimite
228. Calaverite
229. Clinozoisite
230. Copiapite
231. Danburite
232. Fergusonite
233. Gay-lussite
234. Glauconite
235. Halloysite
236. Howlite
237. Hydromagnesite
238. Hydrozincite
239. Linnaeite
240. Loellingite
241. Phosgenite
242. Samarskite
243. Stannite
244. Stephanite
245. Sylvanite
246. Thorite
247. Torbenite
248. Tridymite
249. Trona
250. Xenotime

(11)

251. Adamite
252. Allophane
253. Aurichalcite
254. Calomel
255. Chloropal
256. Clinoclasite
257. Dufrenite
258. Fayalite
259. Gersdorffite
260. Hauynite
261. Jarosite
262. Ludwigite
263. Melilite
264. Mercury
265. Microlite
266. Mirabilite
267. Olivenite
268. Perovskite
269. Petalite
270. Pharmacosiderite
271. Pyrochlore
272. Saponite
273. Tetradymite
274. Triplite
275. Zinkenite

(12)

276. Alunogen
277. Babingtonite
278. Baddeleyite
279. Brazilianite
280. Chalcopyllite
281. Childrenite
282. Chloritoid
283. Dyscrasite
284. Euxenite
285. Gadolinite
286. Gehlenite
287. Glaucodot
288. Helvite
289. Leadhillite
290. Mordenite
291. Natron
292. Piedmontite
293. Pisanite
294. Pollucite
295. Roscoelite
296. Skutterudite
297. Sperrylite
298. Sussexite
299. Tellurium
300. Thenardite

—JEROME M. EISENBERG

New Books

POPULAR GEMOLOGY

RICHARD M. PEARL

John Wiley and Sons, New York, 1948
317 pp., 115 illustrations — $4.00

This is the newest semi-technical book on the science of gems. It is the first book on gems ever published by the firm which has issued all the Dana mineral books since 1844.

Appropriately, then, the arrangement of gems in *Popular Gemology* follows the new 7th edition of *Dana's System of Mineralogy,* although only one of the three volumes has yet been published. Mineral families, series, and species are emphasized as the natural units.

The descriptive chapters have been divided primarily according to the preferred major style of cutting, facet or cabochon, which in turn depends upon the fundamental optical properties of each gem.

The new classification of minerals, climaxed by the 7th edition of *Dana's System,* is based on the new science of crystal chemistry. Recognizing the difficulty that most readers have in studying crystals, the author has begun his discussion of gem properties with their chemistry, devoting more than average space to it. Crystals are taken up next, followed by optical properties, physical properties, and the origin and occurrence of gems.

Professor Pearl is a member of the geology department of Colorado College, and his book is written from the standpoint of a teacher, explaining the principles of gemology clearly and simply, without sacrifice of accuracy.

Written since World War II, the locality information, production data, and uses of gems are up to date.

Appealing to American mineral collectors and amateur lapidaries, to whom the quartz gems are of especial interest because of their variety and abundance, a separate chapter covers the "Gems of the Silica Group," including quartz, chalcedony, opal, and natural glass.

The widespread popular interest in fluorescence and phosphorescence is indicated by the chapter "Luminescent Gems," the first on this subject in any American book on Gemology.

Other chapters deal with the organic gems ("Gems with a Genealogy") and with synthetic, imitation, composite, treated, and cultured gems ("Man-Made Gems").

There is a section on selected reading and an unusually comprehensive and painstaking index of about 3,000 entries. The illustrations number 115 photographs and drawings.

This book is being published in New York by Wiley, and in London by Chapman and Hall, Ltd. Since the author (a Certified Gemologist) is a fellow of the Gemmological Association of Great Britain and Honorary Vice-President of the Gemmological Association of Australia, *Popular Gemology* will have an international distribution.

CALIFORNIA GEM TRAILS

DAROLD J. HENRY

Mineralogist Publishing Co.,
Portland Oregon, 1948
63 pp., 32 illustrations. — $1.50

This well-illustrated volume is concerned with a number of California mineral and gem localities, particularly those in southern

Cailfornia. It is written in a light vein and makes pleasant reading for the collector planning a trip to this region. Excellent directions are given for reaching each locality, and 17 sketch maps made by the author help solve any difficulties encountered in reach'ng these places. Included among the areas described are Imperial County, San Diego County, Riverside County, San Bernardino County, Kern County, Ingo County, and Santa Barbara County.

GEM CUTTING

J. DANIEL WILLEMS

The Manual Arts Press,
Peoria, Illinois, 1948.
224 pp., 94 illustrations — $3.50

Based upon the author's extensive experience in the field of gem cutting, this book should prove to be a valuable guide for both the amateur gem cutter and the professional lapidarist.

A complete, well-illustrated chapter is devoted to the "potato" method of learning to cut facets, thus sparing the beginner the loss of some of his precious cutting material. Clear and accurate step-by-step drawings of facet planning and cutting are presented to the reader, as well as an analysis of the characteristics of the facet-cut gems.

Cabochon cutting is also completely covered from selecting the stone to marking it for the design and finishing it to a mirror-like polish.

This book covers such subjects as how to recognize good quality stones in the rough; principles of light reflection; the construction of equipment; planning, marking, sawing, grinding, and polishing; optical properties of the gem materials; diamond cutting; and, of course, a chapter on the famous Willems' faceting device.

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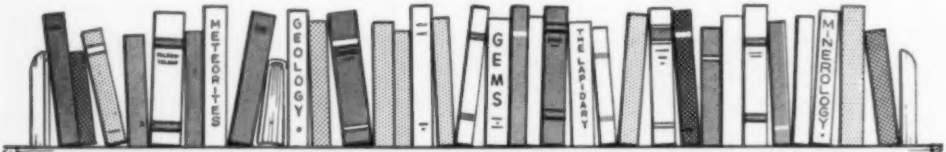

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